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3 ASYMMETRIC TOW SYSTEM FOR MULTIPLE LINEAR SEISMIC ARRAYS

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5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and  
7 used by or for the Government of the United States of America  
8 for governmental purposes without the payment of any royalties  
9 thereon or therefor.

10

11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 This invention generally relates to a device for towing  
14 long multiple line arrays.

15 More particularly, the invention relates to a device for  
16 towing long multiple linear arrays with a streamlined  
17 composite tow cable, with the composite tow cable having  
18 direct mechanical and electrical connections to each towed  
19 array.

20 The array towing arrangement and bridle configuration  
21 present minimal drag to the tow platform and consequently the  
22 proposed arrangement can be towed at greater speeds than other  
23 more traditional towing arrangements. The reduced drag  
24 enables higher tow speed and in turn more rapid coverage of  
25 large areas of the ocean floor.

1 (2) Description of the Prior Art

2       The current art for undersea oil exploration is guided by  
3 seismic analysis of the ocean floor. Large surface ships 90  
4 tow multiple linear arrays 92 equipped with low frequency  
5 acoustic transmitters and receivers (see FIG. 1). An array  
6 catenary 94 trails from the tow platform/ship 90 and is  
7 supported by interconnecting cables 96 at a location of a pair  
8 of depressors 98, one at each of the outer spread of the  
9 interconnecting cables 96 as shown. These arrays 92 send  
10 powerful seismic impulses into the sea floor. The received  
11 echo provides information about the geological make-up of the  
12 ocean floor and also provides indications as to the location  
13 of natural resources. The individual linear arrays 92 can be  
14 many miles long and the bridle holding many arrays can be  
15 several miles wide. The combined drag of the required  
16 depressors 98, interconnecting cables 96, and array catenaries  
17 94 can be enormous. This drag limits the operational speed of  
18 the tow platform 90 and consequently the rate at which the  
19 ocean bottom can be explored. Because the tow platform 90  
20 must be extremely powerful to tow the large arrays, the  
21 operational costs are very high. An improved tow  
22 configuration which reduces the total array drag and thus  
23 enables more rapid seismic surveys is needed in the art.  
24 Correspondingly, a reduction in the required tow platform  
25 scale could save the ocean exploration industry time and  
26 resources.

1       The following patents, for example, disclose towing  
2 cables and towed arrays, but do not disclose an asymmetric tow  
3 system with a streamlined composite cable having both an  
4 electrical and mechanical connection to each of plural towed  
5 arrays.

6           U.S. Patent No. 4,317,185 to Thigpen et al.;

7           U.S. Patent No. 5,089,668 to Harvey;

8           U.S. Patent No. 5,274,603 to Zibilich, Jr. et al.;

9           U.S. Patent No. 5,408,947 to Curto et al.;

10          U.S. Patent No. 5,532,975 to Elholm; and

11          U.S. Patent No. 5,913,280 to Nielsen et al.

12       Specifically, Thigpen et al. discloses a towing link  
13 consisting of a spaced-apart head and tailpieces. The  
14 headpiece includes a towing eye and a pair of lugs for  
15 receiving the stress members of a streamer and a lead-in  
16 cable. The tailpiece defines a pair of bores through which  
17 the stress member and electrical conductors of the two cables  
18 are inserted and sealed. A pair of mating connector plugs is  
19 provided to interconnect corresponding conductors of the two  
20 cables. The assembly is enclosed in a watertight plastic  
21 boot.

22       The patent to Harvey discloses a towed streamer having a  
23 buoyant core, a data bearer layer surrounding the buoyant  
24 core, an inner jacket layer formed of a resilient material  
25 surrounding the data bearer layer, and an outer jacket layer  
26 surrounding the inner jacket layer, wherein a series of  
27 longitudinally positioned strength members are embedded in the

1 inner jacket layer to extend along the streamer to transmit  
2 tension along the streamer while the streamer is held in the  
3 inner jacket layer.

4 Zibilich, Jr. et al. discloses a marine seismic cable  
5 section with stress members and an internal wiring located  
6 within the cable section in a manner which reduces internal  
7 bending stresses upon the cable section when wound upon a  
8 storage reel. Stress members are at least near a horizontal  
9 plane passing through and at approximately equal distances  
10 from the center line of the cable section. Internal wiring is  
11 located in a vertical crisscrossing pattern down the length of  
12 the cable section. In one embodiment, the cable section  
13 contains an elastomeric filler material to retain and support  
14 stress members, internal wiring and other internal components  
15 at their desired location and to prevent damage to internal  
16 wiring and components due to external stress when the cable  
17 section is wound on a cable reel. Stress relief sections are  
18 also provided to further reduce bending stress within the  
19 seismic cable section in other embodiments. Additional  
20 embodiments to the cable section provide for adapting the  
21 cable section to a bottom cable which is laid on and couples  
22 with the sea floor to detect all three vectorial components of  
23 particle motion resulting from p- and s-waves and to detect p-  
24 waves with a hydrophone. Other embodiments provide for  
25 sealing and termination methods which are compatible with use  
26 of elastomer as a filler material for connecting detectors  
27 disposed within the cable section to internal wiring.

1       Curto et al. discloses a method and apparatus in marine  
2 seismic surveying for towing an optical-electrical towing  
3 cable (lead in) and seismic array (streamer cable) at a  
4 perpendicular distance from the centerline of the towing  
5 vessel using a short, flexible adapter cable section which  
6 optically and electrically connects the lead in to the  
7 streamer cable and which attaches to pivoting arms of a  
8 removable towing bracket which carries the bending loads.

9       The patent to Elholm discloses a positioning device for  
10 seismic equipment which is towed by a seismic vessel and is  
11 designed with a body part which is equipped with wings and  
12 rudders. For the control of wings and rudders, control means,  
13 preferably hydraulic or electrical means are used. The device  
14 further comprises a control unit for processing of signals  
15 which preferably operate exclusively on the basis of  
16 information from the vessel or the ship, instruments for use  
17 in the positioning of the device and a communication system  
18 for the communication between the vessel and the device and  
19 vice versa, preferably electrical, acoustic or optical. It is  
20 further equipped with attachment devices of one or more cables  
21 and floats, which are preferably provided at the front of the  
22 device, and preferably in the vicinity of the wing's  
23 attachment point to the device's body part as well as a power  
24 supply system.

25       Nielsen et al. discloses methods, systems, and towing  
26 bridles, provided to increase spread width, streamer  
27 separation, and number in marine seismic data acquisition.

1 The invention is applicable for towing seismic equipment  
2 behind a marine seismic data equipment handling vessel along a  
3 data acquisition path, the system comprising: a deflector  
4 attached to a deflector line; an equipment handling vessel  
5 attached to the deflector; a deflector line pulling vessel  
6 attached to the deflector line; and the marine seismic data  
7 equipment attached to the deflector line.

8 It should be understood that the present invention would  
9 in fact enhance the functionality of the above patents by  
10 providing a streamlined composite tow cable with both  
11 mechanical and electrical components therein for mechanically  
12 supporting and electrically connecting the towed arrays to a  
13 tow platform.

14

#### 15 SUMMARY OF THE INVENTION

16 Therefore, it is an object of this invention to provide  
17 an asymmetric tow system for multiple linear arrays.

18 Another object of this invention is to provide an  
19 asymmetric tow system having a composite tow cable with direct  
20 structural and electrical connections to multiple linear  
21 arrays.

22 Still another object of this invention is to provide an  
23 asymmetric tow system which eliminates multiple individual  
24 linear array catenaries.

25 A still further object of the invention is to provide an  
26 asymmetric tow system for multiple linear arrays which reduces  
27 system complexity.

1           In accordance with one aspect of this invention, there is  
2 provided an asymmetric towing system for towing multiple  
3 linear arrays including a tow platform and a single composite  
4 tow cable extending from the tow platform. The single  
5 composite tow cable has the multiple linear arrays connected  
6 both mechanically and electrically thereto. The composite tow  
7 cable is shaped by a hard streamlined casing and houses a load  
8 bearing cable for mechanical connection to each array and  
9 plural individual array connections for establishing  
10 electrical communication between each array and the tow  
11 platform. A single depressor is connected to a distal end of  
12 the composite cable for spreading the composite cable in a  
13 substantially lateral direction from the tow platform.

#### 14 15                           BRIEF DESCRIPTION OF THE DRAWINGS

16           The appended claims particularly point out and distinctly  
17 claim the subject matter of this invention. The various  
18 objects, advantages and novel features of this invention will  
19 be more fully apparent from a reading of the following  
20 detailed description in conjunction with the accompanying  
21 drawings in which like reference numerals refer to like parts,  
22 and in which:

23           FIG. 1 is a schematic view of a multiple towed array  
24 system of the Prior Art;

25           FIG. 2 is schematic diagram of an asymmetric towed array  
26 system according to a preferred embodiment of the present  
27 invention;

FIG. 3 is an end sectional view of a load bearing cable of the towed array system of the present invention; and

FIG. 4 is a top sectional view of the load bearing cable of FIG. 3.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

In general, the present invention is directed to a system 10 which reduces an overall drag of a towed linear array. The basic system 10 is configured as shown in FIG. 2.

As illustrated in FIG. 2, the system 10 includes a tow platform 12 is provided for pulling the system 10. The tow platform 12 is generally a large ship with suitable cable handling equipment (not shown). A support cable 14 is connected directly to the tow platform 12 and is spread therefrom in a substantially lateral direction by a depressor member 16. Depressor members 16 are well known in the art. Plural towed arrays 18 are directly connected to the support cable 14 in a manner which will be further described below. Support cable 14 is preferably streamlined and made from composite materials.

Specifically, the support cable 14 is shown in detail in FIGS. 3 and 4. From these Figures, it can be seen that the support cable 14 is streamlined via its drag-reducing wing shaped casing 20 having a nose 22 and tail 24 portion. The shape of the casing 20 aids in the accommodation of elements therein. In particular, a load bearing cable 26 is encased along a length of the casing 20 and at the nose portion 22



1   thereof. Behind the load bearing cable 26 are a plurality of  
2   individual array connections 28. These individual array  
3   connections 28 will connect with a respective one of the towed  
4   arrays 18 in order to transmit signals from the linear array  
5   18 through the composite cable 14 to the tow platform 12.  
6   These signals can be electrical or optical signals. The  
7   linear array 18 is additionally mechanically connected to the  
8   load bearing cable 26.

9       Thus, the support cable 14 forms the catenary between the  
10   tow platform 12 and the depressor 16. This cable is an  
11   assemblage of the array connections 28 for each individual  
12   array 18 and a load bearing cable 26. The cable components  
13   are encapsulated by a hard cable fairing or casing 20 shaped  
14   into a streamlined form.

15       Referring again to FIG. 2, the tow platform 12 will move  
16   forward at 30 with the ship axis at a slight angle to the  
17   direction of the assembly motion. This crabbing motion is  
18   required to compensate for the lift (shown as direction 32)  
19   generated by the depressor 16 used to spread the system 10  
20   apart. The action of a ship thruster alone might be capable  
21   of providing the required force vector, however, stabilizing  
22   fins or a keel (not shown) would be another means of  
23   generating the required horizontal force. Even without a  
24   large keel, the ship hull itself will generate some lift when  
25   operated in this crabbing motion.

26       The arrays 18 are very long linear arrays which can  
27   contain hydrophones and seismic transmitters (not shown).

1 There is nothing unique about these arrays 18 for the  
2 disclosed system except that they structurally join and are in  
3 communication with the support cable 14, transmitting their  
4 drag load to and communicating with this cable. The signal  
5 connections 28 continue inside of the support cable 14 to the  
6 tow platform 12.

7 The system operation is not unlike known towed cable  
8 systems. The depressor 16 is deployed which pulls the support  
9 cable 14 across the flow. The combined drag of the arrays 18  
10 and the support cable 14 force the cable into a catenary. The  
11 tow platform 12 must produce a force to overcome the total  
12 drag 34 of the cable system and a lift force 32 to overcome  
13 the tangential drag on the support cable 14 and the lift  
14 produced by the depressor 16. As explained, the normal lift  
15 produced by the ship hull during crabbing motion, lift  
16 produced by stabilizers and the ship keel, and the ship thrust  
17 can be combined to generate the required horizontal forces.

18 The proposed concept is based on replacement of a dual  
19 depressor system with a single depressor system. The  
20 individual cable catenaries are replaced with a single  
21 streamlined support cable, and the cross-cables are eliminated  
22 from the system. The thrust of the ship and hull lift forces  
23 are used to compensate for the lift produced by the depressor.

24 The proposed system configuration will provide an  
25 improved multiple towed array design by eliminating multiple  
26 individual catenaries, eliminating cross cables which are  
27 normal to the direction of ship motion, reducing the number of

1 required depressors to one, reducing the system complexity,  
2 and reducing the number of wetted cables in cross-flow thus  
3 making hard fairings a reasonable engineering solution to drag  
4 reduction.

5       The system configuration presented herein can be  
6 configured in many ways in order to achieve the desired  
7 result. One alternate configuration includes deployment of  
8 two assemblies, each from laterally opposite sides of a tow  
9 platform, in a symmetric configuration, thereby eliminating  
10 the need for ship generated lift. Another alternate  
11 configuration is for two ships (tow platforms) to work in  
12 tandem, with a connecting cable between them to balance the  
13 horizontal loads. These are not exclusive alternatives, and  
14 are suggested only as examples of alternative configurations  
15 of the present invention.

16       In view of the above detailed description, it is  
17 anticipated that the invention herein will have far reaching  
18 applications other than those of towed linear seismic arrays.

19       This invention has been disclosed in terms of certain  
20 embodiments. It will be apparent that many modifications can  
21 be made to the disclosed apparatus without departing from the  
22 invention. Therefore, it is the intent of the appended claims  
23 to cover all such variations and modifications as come within  
24 the true spirit and scope of this invention.